VOLUME XXXVII NUMBER 7 WHOLE NUMBER 326

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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PUBLISHED MONTHLY
(*Ten numbers per year*)

September, 1943

PRINTED FOR THE SOCIETY
TORONTO: 198 COLLEGE ST.

THE JOURNAL
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Address of Editors: David Dunlap Observatory, Richmond Hill, Ont.

Business correspondence, remittances, etc., should be addressed to J. H. Horning, Treasurer of the Society, 198 College Street, Toronto 2B, Ontario.

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PLATE VIII

MR. WATES PRESENTING THE EYE-PIECE OF THE TELESCOPE TO PRESIDENT NEWTON.

PHOTOGRAPH TAKEN FOLLOWING THE CEREMONY.

Those in the front row are (left to right): Dr. J. R. Tuck, Dr. A. McKellar, Dr. J. W. Campbell, Dr. J. A. Pearce, Lieut.-Governor J. C. Bowen, Mr. C. G. Wates, Dr. R. Newton

Dr. J. A. Pearce, Lieut.-Governor J. C. Bowen, Mr. C. G. Wates, Dr. R. Newton

PLATE X

THE 12½-INCH NEWTONIAN REFLECTOR AND 4-INCH RICHEST-FIELD TELESCOPE.

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THE WATES TELESCOPE AND THE UNIVERSITY OF ALBERTA OBSERVATORY

By J. W. CAMPBELL

(With Plates VIII-X)

ON Thursday, May 20, of this year a formal ceremony was held at which a 12.5-inch reflecting telescope was presented to the University of Alberta and at which the observatory, housing this and a few other instruments, was opened.

The telescope was the gift of Mr. Cyril G. Wates, a valued member and past president of the Edmonton Centre of the Royal Astronomical Society of Canada, and it will stand as a monument to the zeal and skill of the donor, for it was entirely designed and constructed by him. A technical employee of the Edmonton telephone department, Mr. Wates is a man of exceptional mechanical ability, and of ardent interest in any hobby which he takes up. For many years he has been an enthusiastic member of the Alpine Club of Canada and he has given himself unstintingly to the service of that organization. Then about twelve years ago he became interested in amateur telescope making, and numerous articles in the *Scientific American* attest the meticulous care and thoroughness with which he pursued this hobby. He soon had a 9-inch telescope completed and this he mounted in a small observatory on the bank of the Saskatchewan River valley just opposite his residence. It is perhaps not unnatural that one who had enjoyed the thrill of viewing vast expanses of terrestrial silent grandeur from mountain peaks should also find pleasure in using his telescope to observe the silent grandeur of the sky.

But Mr. Wates got a two-fold satisfaction from his interest in astronomy. He enjoyed seeing the celestial phenomena when using his telescope, but he also enjoyed the sense of mechanical achievement which he experienced in its making. So he ground other mirrors and made other telescopes, and in 1937 he began the grinding of a 12.5-inch mirror. The grinding was done by hand but the polishing and figuring were done on a mechanical grinding machine which he himself had made.* On its completion he offered the telescope as a gift to the University of Alberta on condition they would suitably house it to make it available for use to the University and to the Astronomical Society. The acceptance of this offer was made possible by a grant from the Research Fund Committee of the University to cover the cost of construction of the building.

The building is of frame construction, 20 ft. x 32 ft., and the Wates telescope is housed in a 16-foot dome at the north end. The dome is a duplicate of that built by the Rensselaer Polytechnic Institute at Troy, N.Y., and we gratefully acknowledge the kindness of that institution in supplying us with their blueprints. In the south end there are three piers for other instruments. The east one carries a small transit telescope, the centre one a four-inch refractor, and the west one a two-inch zenith telescope. The last-named instrument is equipped with vernier scales and is well suited for precision work.

Mr. Wates has supplied his telescope with a four-inch richest-field reflector for a finder, an instrument which he had also made himself. In fact the telescope and finder are the two instruments which he captioned "Dignity and Impudence" in the article already referred to. They are shown with him in a photograph which accompanied the article and which is reprinted here as Plate X. Needless to say this four-inch reflector makes an excellent finder, and for the viewing of such objects as the Beehive cluster in Cancer it is the ideal instrument itself. The clock drive is not yet completed but will be added during the summer. It is to be of the type designed by Boyd Brydon and described in earlier numbers of this JOURNAL.

For the opening ceremony on May 20 we were fortunate indeed

**A Hindle Type Grinding Machine* by C. G. Wates, This JOURNAL, Jan. 1941, p. 33.

to be favoured by the presence and participation of Dr. J. A. Pearce, Director of the Dominion Astrophysical Observatory at Victoria, B.C. He was accompanied by Dr. Andrew McKellar, astronomer at the same institution, and the occasion was graced by the presence of Hon. J. C. Bowen, Lieutenant-Governor of Alberta.

The programme was directed by Dr. J. R. Tuck, President of the Edmonton Centre. It consisted of the Presentation by Mr. Wates, the Acceptance by Dr. Robert Newton, President of the University, and an Address and Dedication by Dr. J. A. Pearce. The gathering was not large and the programme was not long but there was a balance and cordiality throughout which made the occasion both a pleasant and a valuable one.

In his remarks Mr. Wates gave an informative description of the work of amateur telescope making and an interesting *résumé* of his own experience in that work. Indirectly they reflected the simplicity and sterling character of his own personality. In accepting the gift Dr. Newton expressed the thanks and gratitude of the University for the generosity of the donor, and also for the telescope as a product of Mr. Wates' own hands.

In his pleasingly informal manner Dr. Pearce congratulated the University on having received the sixth largest telescope in Canada. On the evening before, after reaching Edmonton, he and Dr. McKellar had been taken to the observatory to test the telescope's performance, and he complimented Mr. Wates on the quality of his work. He characterized the performance of the mirror in its resolution of double stars as superb. He gave some interesting historical notes on telescopes such as those of Herschel and Rosse and of what had been accomplished by them, and he directed attention to the value of the observatory as an asset to the teaching facilities of the University and to the possibilities it afforded of extending our knowledge of astronomy.

Messages of congratulation and good wishes had been received from other Observatories in Canada and from other Centres of the Astronomical Society, and the reading of these messages during the ceremony greatly enhanced the pleasure of the occasion.

The whole project has been of special interest to the writer of this

article. He is interested from the standpoint of his department in the University and also from the standpoint of the Edmonton Centre, of which he has the honour to be Honorary President. To all those who had contributed to its realization he expressed a personal word of thanks; to Dr. Newton and members of the Research Fund Committee who had provided the funds for the building, and above all to Mr. Wates for his gift of the telescope and for his advice and assistance in connection with the building of the observatory itself.

The programme was fittingly brought to a close by some remarks from His Honour, the Lieutenant-Governor, who expressed his personal congratulations and also directed attention to the cultural and moral value of the pursuit of astronomy.

University of Alberta,
Edmonton,
July, 1943.

THE DISCOVERY OF A PREHISTORIC ZODIAC IN ENGLAND

By K. E. MALTWOOD

(With Plate XI)

THE zodiacal constellations had been long established when the sun entered the 'sign' Aries at the vernal equinox, but no explanation has been vouchsafed that could account for the notoriety of these 'signs' down the ages.

So the question was: When were they designed, and where, and how, and by whom? Ptolemy (A.D. 150) transmits them from Hipparchus (B.C. 130) "as of unquestioned authority, unknown origin, and unsearchable antiquity."

Historical astronomers realized that the zodiacal constellation 'creatures' did not originate on the ceiling of a temple, the dome of a mosque, or the pavement of a church, where they are still found in many places. The universality of the design proves that the civilization that engendered these signs must have had ramifications not only through Europe, Egypt and the near east, but through India, Persia and the East Indies, wherever sun worship penetrated. They also know that star gazers could only observe these particular constellations, through which the sun rides, in a region answering to Asia Minor, and not so far south as Egypt.

The discovery of a great zodiac laid out among the little hills in the neighbourhood of Glastonbury, in Somerset, England, seems to answer the above queries, for here is apparently the first "Mighty Labour of the Isle of Britain" of which the Welsh bards sang.[1] It has lain prone on the ground for thousands of years, covered with King Arthur's fabled "mantle of invisibility," though seeing every one.

The explanation as to who made it, is that the Cymry of Wales came, according to their traditions, "from the East in the Age of Ages," (Barddas) bringing the knowledge of the stars from Asia Minor, and laid out this zodiac, which they called in the welsh tongue *Caer Sidi*. Dr. L. A. Waddell confirms their traditions in his "Makers of

[1]The second "Mighty Labour" was Stonehenge; see Williams' "Ecclesiastical Antiquities of the Cymry," chap. VIII.

Civilization." He says (page 6): "Detailed proofs are given in my former works for the Sumerian origin of the Cymry with approximate dates for the Sumerian mining and colonizing occupation of parts of the British Isles by several immigrations from the Sargonic period of about 2700 B.C. onwards."

The sophistication of the design of this 'Round Table of the Stars' shows that it was laid out by experts, for no artistic, religious or scientific conception combined with agriculture could transcend its expression. It is artistic in its beautiful composition and virile drawing, religious in that it reflects God's universe and laws, scientific in its stellar observations and geometrical layout. With the 'Children of the Sun' their religion and science were at one.

During thousands of years the zodiac was so much revered that every figure there portrayed was a sacred emblem; for instance, the four evangelistic symbols of the Bull, Lion, Man and Bird are found here in Somerset in their proper places at the four cardinal points, i.e., Taurus, Leo, Sagittarius and Aquarius,[2] whereas on modern maps there is no bird amongst the zodiacal constellations. It follows that these Christian symbols were founded on this original design, and correspond to the standard of Sargon II, King of Assyria.[3]

Temples as we understand them, were not great enough to contain the constellations; so mother Nature was chosen to sustain them, and the thirty-mile circumference of this sacred area was looked upon in its beginning as the 'Cauldron of unfailing supply': it had three properties—inexhaustibility, inspiration, and regeneration. We are told by the Welsh bards, the descendants of the Cymry, that it was stolen from the 'Divine Land' for it was Annwn itself. Taliesin, who knew most about it, sings in "The Spoils of Annwn"[4] of the recovery by Arthur of the magic Cauldron of inspiration and that it was found at Caer Sidi, the zodiac.

This Cauldron was associated with a Druid cult before it became the Christian Grail, both in Norman romance and Welsh literature it possessed the same characteristics.

---

[2]"Ancient Calendars and Constellations" by Plunket, published 1903. On the Roman zodiac Aquarius was represented by a peacock.

[3]*Ibid.*

[4]See "The Mysteries of Britain," by Lewis Spence, page 121.

I have been teacher to all the universe;
I shall be until the day of doom on the face of the earth;
I have been in a toilsome chair above the Zodiac,
Which revolves between three elements.
Is it not a wonder that the world discerns me not?

Taliesin was the "official" bard of the mysteries of this Caer Sidi, and boasts he was present with Arthur when he stole the Cauldron; he was also the son of the goddess of the Cauldron. When Merlin entered the glass house the treasure of Britain vanished with him, the plentiful feeding vessel with the rest;[5] thus what has now been recovered was thought to have been lost, though it was said to have been capable of feeding all the world.[6]

In "The Arthurian Legend" by J. Rhys (page 345) we read:

"But we are here more particularly interested in Glastonbury, the identification of which with Avallach's Isle, and all that term was supposed to connote . . . would also lead to the further conclusion that it was naturally the 'Land of Summer,' which in the form *Somerset* has become fixed as the name of the county to which Glastonbury belongs."

So it is not surprising that Somerset yielded up the secrets of the Summer country[7] and that the discovery of the 'Star Giants' was the result of making maps to illustrate the twelfth century romance called "The High History of the Holy Grail."

---

[5]See John Rhys's Hibbert Lectures, 1886.

[6]"The Mythology and Rites of the British Druids," by Edward Davies, published 1809, pages 295 to 299.

See "The Air View Supplement to Glastonbury's Temple of the Stars," where E. Davies is quoted in full under the heading "Caer Sidi."

[7]We read in "Druidism" by the Rev. John William Ab Ithel, published 1871, page 13: "The science of Hu the mighty was preserved by the wise men of the nation of the Cymry and that he was the first to lead the Cymry over into the Isle of Britain, from the Summer country and that the creative Name of Light was recovered to memory whilst the Cymry were still in the East." Dr. Waddell says in his "Origin of Britons and Scots," page 190: "We discover that the 'Cymry' of Wales derive their name from 'Sumer'; this latter was a term occasionally used by the early ruling race in Babylonia, the Sumerians of modern Assyriologists." The First Triad says: "There was no tribute paid to any but to the race of the Cymry because they first possessed the Isle of Britain." The Sixth Triad supplementing this one says: "First Hu Gardarn originally conducted the nation of the Cymry into the Isle of Britain. They came from the Summer Country over the hazy sea."

Thus in tracing the quest of the Knights of the Round Table between the famous Avalon Isle, King Arthur's Castle of Camelot, and Wales, it was found that Sir Lancelot and the other knights quested roughly in a circle over the same ground, encountering a Lion, Giants, and a fiery Dragon.

Years of puzzling over the mystery as to what they were really questing, obviously not a Christian Grail, revealed that the Cary River in its windings, drew the outline of a Lion, the two Dundon hills formed a Giant, and so on. Thus here were Knights hunting 'Nature Gods,' but they themselves were the Christian reincarnations of the gods they quested, or perhaps astrologers might say they were born under those particular stars, Sir Lancelot showing all the characteristics of the Lion, King Arthur of the sun god Hercules, Sir Gawain of the Ram, etc.

This then explained "the wonders of Great Britain," and "the great adventurers of the Kingdom of Logres"[8] for here we have a dual myth of earth and sky—the star constellations laid out on earth, and the Knights impersonating the stars above them. A magnificent conception!

The Description of This Zodiac

So it is in Somerset, England, that we have discovered what King Arthur's 'System of the Round Table' really was. "A Guide to Glastonbury's Temple of the Stars," and its "Air View Supplement" fully illustrates and describes it.[9]

This zodiac or agricultural calendar, is surrounded on three sides by hills, about one thousand feet high, which are crowned by prehistoric forts. On the west flows the Severn sea with Wales on the opposite shore. Within this natural enclosure, the low-lying hills are shaped to form the star constellation giants.

Outlining the design to a great extent are two small rivers that have not changed their course, being penned in by the little hills of this mysterious Kingdom of Logres, as "The High History of the Holy Grail" calls it.

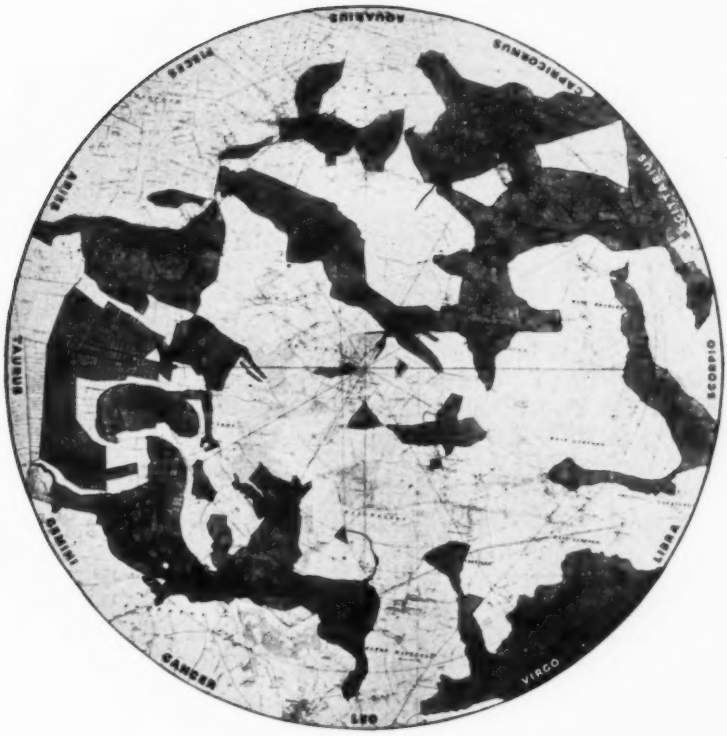
---

[8]"The Legend of the Holy Grail," by Nutt.

[9]By K. E. Maltwood, F.R.S.A., published by John Watkins, 21, Cecil Court, Charing Cross Road, London, W.C.2, Price 5/- each.

PLATE XI

North



South

Map of the Zodiacal Giants of Somerset

The effigies correspond with the stars of their respective constellations.

Journal of the Royal Astronomical Society of Canada, 1943.

From the realistic drawing of the 'Creatures,' which are superb in outline, from the demonstrated knowledge of irrigation, and earthwork construction of a high order, from the apparent date of the equinox, about 2700 B.C., and from tradition, this planisphere strongly suggests the culture of the Euphrates, and has no connection with the monolithic stone monuments of Avebury and Stonehenge.

In order that the design should fit the dome of the sky and the twelve zodiacal divisions of the calendar, with their corresponding stars, the figures are so arranged as to contract towards the centre of the circle of signs; an amazing achievement considering that most of them measure three miles long, but the whole composition is astonishingly skilful.

As the Lion and Scorpion[10] were then double the size they are now represented on star maps, they here occupy the place of the Crab and Scales respectively as well as their own.

The figures lying towards the north of the circle represent the winter months—the Scorpion, Archer, Goat, Water-carrier and Fishes attached to the Whale.

Opposite are—the Ram, Bull, Twins, Lion and Virgin. Thus they correspond, in regard to their order, as they do in their traditional characteristics, with those seen on astronomical globes in use at the present day; but the modern copies of these constellations have lost the rhythm and meaning of the original conception.

For instance, the drama of these winter months is, that the Scorpion of death has stung the Archer's horse, causing it to fall forward, as this old sun-god shoots his last ray into the 'Bull's Eye.' In consequence he dismounts from his horse's neck, giving the impression of a centaur as on modern star pictures.

The feet of both horse and rider are already hidden by the earth sign Capricornus, for the Archer represents the end of the year; thus the sun-god has 'one foot in the grave,' for the great earthwork forming the Goat's bronze age horn is called locally "the Golden Coffin"

[10]The Alexandrian Zodiac is said not to have contained the Balance, and its place was occupied by the Scorpion's claws. See "Oedipus Judaicus" by Drummond, pub. 1811. Of the Scorpion Ovid says:

"In the wide circuit of the heavens he shines
And fills the place of two zodiacal signs."

and the stars that correspond are Job's Coffin. In accordance with Druid belief and mediaeval art, the Whale lies in wait for his soul, mouth open towards the pole of the ecliptic, and this Whale is the only effigy constellation thus to face east. It is entirely outlined by waterways.

The Water-carrier, being an air sign, is here represented by a Phoenix, holding the vessel of water in its beak. It is fanning its burning nest with its outstretched wings. Glastonbury's famous Isle of Avalon, towering 600 feet out of the marsh, forms this bird, and the Urn contains the life-giving 'blood spring' known far and wide as Chalice Well; its waters are radio-active and stain the stones over which it flows blood red.

"The First Church of Britain," that is to say the wattle Chapel of St. Joseph of Arimathea, and afterwards Glastonbury Abbey, were built upon the tail of this Phoenix. Consequently it was hallowed ground long before the pagan king gave it to the Christians; for the Isle of Avalon was known through Europe as the 'Island of the Blest, Avalon, the place of departed spirits.'[11] There is much legendary history connected with the subject, but all we can touch on now is its foundation in the 'Round Table of the Stars.'

To continue its description: After the Fish, the young Ram and the Bull, the drama of the summer months is the apotheosis of the regenerated sun and nature represented by the solar babe sitting in his moon boat, for the first Twins were the sun and moon. Around him cluster adoring animals, the Bull, Lion, Little Dog, and Griffon, which is part of the rudder of the Ship; whilst the Virgin with outstretched wheat-sheaf offers to him the fruits of the earth on bended knee.

The unusual features of the whole composition are: first, that the only human beings represented, are the Father, Mother and Child, and that the old bearded sun-god Hercules, who rides the horse of Sagittarius, points with the first finger of his right hand to the exact centre of the circle of the signs, but this centre is neither the pole of the ecliptic, nor that of the pole star Thuban (Alpha Draconis). This finger is repeated on a much larger scale in order to lie along the line of the equinox, pointing directly into the eye of the Bull,

[11]"Highways and Byways of Somerset" by Edward Hutton.

and in alignment with the royal stars, Aldebaran and Antares in Scorpio.

Another very marked feature of the design is that the heads of eleven figures turn towards the sunset over the sea which lies due west, for the equinoctial line between Aldebaran and Antares runs west and east.

When designing this chart of the stars, as much emphasis was laid on the path of the sun as upon the position of the equinox, for the 'Solar Babe' with upraised arm holds on to the central line of the ecliptic by the two stars of Gemini that lie upon it.[12] The Virgin's Wheat-sheaf and the Ram's (traditionally) reverted head are made to measure the width of the sun's path, and the Bull and Lion point it out with their right feet and the Lion's tongue, which is an interesting feature, being made of red earth.

The astonishing knowledge and skill displayed in laying out these star figures on the earth, places this solar calendar in a unique position in regard to archaeological survivals, hence the traditional sanctity of the neighbourhood around Glastonbury, 'The Temple of the British Secret Tradition,'[13] for it constituted a laboratory of thought and mystery, recognized by the races of the continent of Europe as unspeakably hallowed and inscrutable.

The astronomer M. Proctor remarks: "Learned antiquarians have searched every page of heathen mythology, and ransacked legend, poetry and fable, in a vain endeavour to discover who were the inventors of the constellations, but without avail." So the subject of the origin of these signs is full of interest to the chronologist who inquires into what era of the world exact astronomy began and when the sun was assigned his twelve zodiacal constellations.

The discovery of this unique zodiac should solve the problem of when, where and how the Constellations were designed, and English history points the direction from whence the inventors came. 'Hu the Mighty' had brought the Cymry from the Summer country to the Isle of Britain in the 'Age of Ages'; after which the first king

[12]Delta was called Wasat, 'the middle,' by the Arabians.

[13]See "The Mysteries of Britain" by Lewis Spence, page 191.

of Britain was of the royal house of Troy.[14] When he was sent to 'Albion' this Brutus was told that there were giants in the land, supposedly Hercules, Orion and the rest of these giants born of heaven and earth.

Troy in Asia Minor fulfils all the conditions laid down by Maunder, such as, the region from which the stars of these particular constellations were observed, the animals chosen to represent them and the knowledge of ship building.

> Brute,—past the realms of Gaul, beyond the sunset
> Lieth an Island, girt about by ocean,
> Guarded by ocean—erst the haunt of giants,
> Desert of late, and meet for this thy people.
> Seek it! For there is thine abode for ever;
> There by thy sons again shall Troy be builded;
> There of thy blood shall Kings be born, hereafter
> Sovran in every land the wide world over.[15]

Victoria, B.C.

[14]See "Druidism" by J. W. ab Ithel, page 7; and Geoffrey of Monmouth's "Histories of the Kings of Britain," page 14.

See Schliemann's "Troja," and the British Museum "Bronze Age Guide." Hissarlik, the first city of Troy, belonged to the Mycenean age and the dawn of the bronze age, which agrees with the date of our findings in Somerset. Apart from history, Sir Hercules Read said, speaking for the British Museum: "Bronze torcs are common in the south west of England, a clue to their date is given in a gold torc which was found by Schliemann in the royal treasure of the second city of the hill of Hissarlik, which preceded the Homeric city of Troy by about a thousand years." Both Canon Greenwell and Sir Arthur Evans drew attention to the "Owl Face of Hissarlik," dated 2700 B.C. which reached Britain on such objects as the chalk drums belonging to the early age of metal. Many archaeological relics as well as tradition and folklore throw light upon the ancient landmarks of this Temple of the Stars.

[15]Quoted from Geoffrey's "History of the Kings of Britain." Milton says: "These Verses, originally Greek, were put in Latin (saith Virunnius), by Gildas, a British Poet, and him to have liv'd under Claudius."

THE COMPOSITE BINARY SYSTEM H.D. 144208-9

By R. M. Petrie

Introduction

AMONG the many thousands of stars which have their spectra examined and classified there are a few hundred which are described as having "composite" spectra. A composite spectrum is one which exhibits, simultaneously, the characteristics of two separate spectral classes; it is as though two sources, at different temperatures, were combined to produce the observed spectrum. In a great majority of cases the composition is indeed produced by two stars which are too close together to be resolved as a double star by the telescope. For such systems Hynek[1] has suggested the term "spectrum binaries" and he finds that more than 70 per cent. of all composite spectra arise in these physically connected double stars.

The binary system, H.D. 144208-9, to be described in this paper, is a "spectrum binary". The component stars are not resolvable telescopically but they are close enough together to pursue orbital motion which can be studied spectroscopically through the variation in radial velocity. This binary then forms a link between the short-period spectroscopic binaries and the wide pairs resolved telescopically. A detailed study of the system appeared to be well worthwhile since we possess only meagre data about the masses, dimensions and position in the evolutionary sequence of the "spectrum binaries".

Another point of interest has been revealed by this study, namely, the peculiar nature of the fainter component. The system is found to be composed of a normal star resembling the sun in size and brightness and a fainter sub-luminous A-type star of the sort recently designated "sub-dwarf". This star is about one one-hundredth of the brightness of a normal A star, much smaller in diameter and its mean density is very great, about thirty times that of the sun or one thousandfold that of a normal A-type star. It follows from this study that, among the composite systems, many

[1] *Contr. Perkins Obs.*, No. 10, 1938.

such sub-dwarf companions may be revealed by spectroscopic investigation.

The observations and calculations described in this paper fall into two sections, as follows, (*a*) radial-velocity measures leading to the period of revolution, the orbital elements and the mass-ratio, and (*b*) spectrophotometric measures permitting the determination of the relative brightness of the components and the spectral class of the fainter star. Combination of the results allows the calculation of the probable dimensions of the orbits and the masses and diameters of the component stars.

Section 1. The Radial Velocities and Orbital Elements

The variable nature of the radial velocity of H.D. 144208-9 was announced by Christie and Wilson[2] at the Mount Wilson Observatory in 1938. The writer undertook the further study of the star in 1939 and was kindly furnished with the individual velocities by the Mount Wilson observers. Their observations were obtained during the interval between 1925 and 1936 and were therefore of the greatest help in determining the final value of the period of revolution. Altogether there were 61 spectrograms yielding radial velocities for the orbit determination. The Victoria spectrograms were secured with single-prism dispersion, the majority with the medium focal-length camera giving a linear dispersion at Hγ of 30 A./mm., while 10 spectra were obtained with a shorter camera giving a linear dispersion of 51 A./mm.

The spectrum resembles, generally, that of an average F5 star containing many sharp lines of metallic atoms. These lines, however, are reduced in contrast owing to the presence of the continuous spectrum of the fainter star. After a few plates had been measured it was apparent that the radial velocity determined from the *K*-line of Ca II did not agree with those found from the other spectral features. In this way the presence of the fainter component was revealed and its velocity variation determined. A search for other lines belonging to the fainter star was made but no feature, save *K*, could be found to give velocities other than those of the brighter star. Indeed, the composite nature of the spectrum might have

[2] *Astroph. Jour.*, vol. 88, p. 34, 1938.

escaped detection were it not for the fact that the broad and strong, absorption line at the *K* region, in the spectrum of the brighter star provides a "window" through which we may detect and study the spectrum of the fainter companion. This effect was illustrated to a greater degree in a recent study of β Capricorni by Sanford.[3]

The velocities of the fainter star rest, then, upon measures of the *K*-line only. For the brighter component 10 spectral lines were measured on the average plate. These lines were selected after a study of their individual velocities and intensities showed that they were not affected by the spectrum of the fainter star, except for the reduction of contrast already noted. The spectrograms were measured for radial velocity in the usual manner upon the projection micrometer. Since the radial velocities of the solar-type star were of much greater accuracy than those of the companion, only the former were employed in the determination of the general orbital elements; the radial velocities of the fainter star were used only to determine the amplitude of its motion, and this they do with all necessary precision.

Preliminary trials indicated that the period was slightly greater than 100 days and the value finally adopted is 108.075 $\pm$.021 days. Since this value is calculated from observations extending over some 54 cycles it was not necessary to include it in a solution for corrected elements and so the observations were grouped into normal points. A graphical study of the radial-velocity curve showed that the orbit must be nearly circular. The eccentricity was estimated as being less than 0.05 and it was not possible to assign a value to ω with any degree of confidence. It is well known that, under these circumstances, a least-squares solution for corrections to the elements, using the conventional formulae, introduces difficulties. It was therefore decided to employ the method devised recently by Sterne[4] wherein a set of preliminary circular elements is corrected to a set containing a small eccentricity. The procedure as applied to these observations was found to be rapid and very satisfactory, affording a good example of its practical value to the computer.

Preliminary circular elements, as shown in Table I, were ob-

[3] *Astroph. Jour.*, vol. 89, p. 333, 1939.
[4] *Proc. Acad. Science*, Wash., vol. 27, p. 175, 1941.

tained from the normal points and the following normal equations resulted:

$$\begin{aligned}
25.100x - 2.118y + 1.922z - 3.144u + 1.206v + 5.197 &= 0,\\
+13.511 - 0.025 + 2.354 - 1.570 - 5.229 &= 0,\\
+14.517 + 0.675 + 1.148 + 0.689 &= 0,\\
+10.583 - 2.093 - 2.198 &= 0,\\
+11.588 - 0.963 &= 0,
\end{aligned}$$

where

$$x = \delta V_0,\ y = \delta K,\ z = Ke\cos\omega,\ u = Ke\sin\omega,\ v = Kn\delta T_0.$$

The solution of these equations gave the final elements together with their probable errors as listed in Table I. The corrections to V_0, K_1, and T_0 were small and the solution lowered the value of Σpvv by only 3 per cent. The small value of the eccentricity and the probable errors in it, and in ω, show that the orbit is circular, in so far as these observations can discriminate. Circular orbits with the values of P, T_0, K_1, K_2 and V_0 as tabulated should therefore be adopted. The probable error of a plate of average weight is $\pm$ 2.1 km./sec.

TABLE I

ORBITAL ELEMENTS OF H.D. 144208-9

	Preliminary	Final
P	108.075 days	108.075 ± 0.021 days
T_0	J.D. 2429765.376	J.D. 2429765.532 ± 0.432
T	.....	J.D. 2429798.810 ± 61.086
ω_1	.....	110° 52′ ± 203° 31′
e	0.00 (assumed)	0.006 ± 0.026
K_1	19.25 km./sec.	19.61 ± 0.45 km./sec.
K_2	25.00 "	23.16 ± 0.93 "
V_0	−1.75 "	−1.92 ± 0.33 "
$a_1 \sin i$	.....	29,100,000 kms.
$a_2 \sin i$	.....	34,400,000 "
$m_1 \sin^3 i$	.....	0.48 ⊙
$m_2 \sin^3 i$	.....	0.40 ⊙

After these results were obtained a solution was made to determine the amplitude of the radial-velocity curve of the fainter star, based upon the measurements of the K-line. The final value of K_2, so determined, and its probable error, are given in Table I. The probable error of a plate of average weight for the secondary star

is ± 8.9 km./sec. and this is considered to be satisfactory since the velocities depend solely upon the *K*-line and this feature is not well defined unless the spectra are very strongly exposed.

The radial-velocity curves are shown in Fig. 1 where individual observations are plotted for the primary star and normal points for the secondary. The Mount Wilson observations are indicated by crosses and the Victoria plates by filled circles, while the normal points for the secondary are represented by open circles.

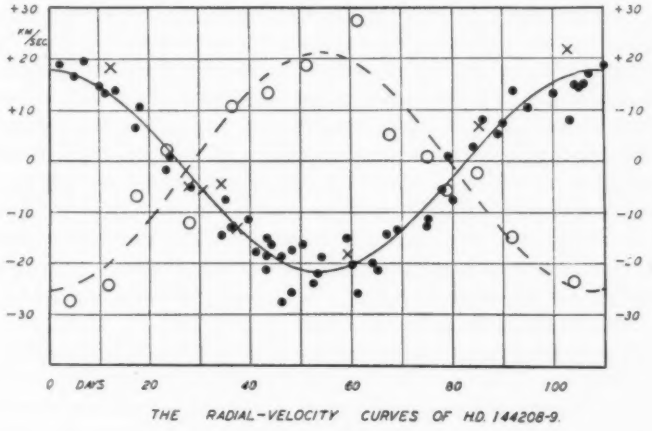


Fig. 1

Section II. Spectrophotometric Measurements

In a composite system which combines the spectrum of a brighter solar-type star with that of an A-or B-type fainter companion, the composition is detected by certain deviations from the normal appearance of the solar-type spectrum. The most striking of these are:

(i) a weakening of the absorption lines due to neutral metals, such as Fe I, Ti I, Cr I, etc., this effect becoming more pronounced at shorter wave-lengths;

(ii) a pronounced weakening of the normally strong *K* line and a strengthening of the wings of the Balmer lines of hydrogen; and,

(iii) an extension of the spectrum to the violet of λ3900, not usually encountered in the later-type spectra.

It was proposed to investigate the spectral properties of the fainter component of H.D. 144208-9 by studying the above effects, especially the second mentioned. In order to do this, spectral-line intensities were determined for a number of lines in the wave-length interval λλ3800-5000 A. The lines K, $H\zeta$, Hδ, Hγ and Hβ and a number of typical solar lines, principally of Fe I, were measured. Line profiles and intensities were obtained in the usual way; the plates were calibrated with a rotating sector and the spectra were analyzed with the self-recording, photoelectric microphotometer.

The first point to be settled is what contribution the fainter star makes to the solar-type lines; does it merely weaken them with continuous spectrum or does it have a share in the formation of the composite lines by reason of having absorption lines of its own at those wave-lengths? This matter may be investigated by comparing central intensities of narrow deep lines in the primary spectrum at two positions in the orbit, viz., when the two stars have the same velocity, that of the system, and when they have maximum separation in velocity, at nodal passage. If the fainter star contributes only continuous spectrum the line-depths will be constant throughout the orbital period, but if it possesses spectral lines corresponding to those in the brighter star then the central intensities will be greatest at nodal passage and least at the time of crossing the V_0-axis. The central intensities of forty sharp lines were measured on two plates at each of the above mentioned orbital phases and show a negative effect, the mean difference in central intensity being -0.04 in the sense nodal passage *minus* systemic velocity. It may be taken, then, that the fainter star contributes only continuous spectrum to the strong lines of the neutral metals. The only other apparent interpretation is that the fainter star may have such lines in its spectrum but that they are of considerable width. This explanation receives no support from an inspection of the tracings since the spectral features show no sign of periodic asymmetry over the orbit. It may be assumed, therefore, that the fainter star is of early spectral type with few absorption lines. This conclusion is strengthened by the absence of periodic blending effects in the radial velocities, discussed in the previous section.

In order to proceed further we must now study the effect produced by the fainter star upon the K line, and the hydrogen lines,

and this requires that we compare the observed features in the composition with those in a normal star of the same spectral type and luminosity. This necessitates a careful classification of the spectrum of the brighter component. The primary star is classified as F5 at Harvard and as F3 at Mount Wilson. Unless the effect of the fainter star is allowed for, however, the later-type spectrum will be classified too early in the spectral sequence, since the early type companion weakens the metallic lines and causes the hydrogen lines to become strengthened over their normal appearance. Using the line intensities from our spectrograms, and the Mount Wilson classification ratios,[5] the apparent spectral type is F4 but, after allowance is made for the continuous spectrum of the secondary it appears that the spectrum of the primary star is about F8. Furthermore, an inspection of the G band reveals that its development is very similar to that in the solar spectrum and so the spectral type dF9 is adopted for the brighter star.

The spectral type of the secondary star cannot be estimated with any certainty from a visual inspection of the plates. It is given as A2 in the *Henry Draper Catalogue* but this is, presumably, based upon the appearance of the *K* line and is liable to serious error. This feature is a blend of a wide strong absorption line and a region of continuous spectrum containing a weaker, narrower, *K* line. Under these circumstances the appearance of the resulting feature does not give an accurate idea of the character of the *K* line in the fainter star. Indeed it can be shown that the combination of pure continuous spectrum with a solar-type *K* line produces a result not unlike that feature in an early A-type star. From other considerations, presented below, the writer assigns the spectral type A0 to the fainter star.

The estimation of absolute magnitude is not influenced by the spectrum of the secondary since ratios of narrow metallic lines in the same wave-length are employed. The writer's measures of the luminosity criteria λλ4071/4077 and λλ4215/4250 are in agreement with the Mount Wilson results[6] and their value of + 3.4 for the absolute visual magnitude of the brighter star has been adopted.

[5] *Mt. Wilson Contr.*, vol. 9, p. 423, 1920; *Trans.* Int. Ast. Un., vol. 5, p. 182, 1935.

[6] *Mt. Wilson Contr.*, vol. 22, p. 57, 1934.

With the above values of spectral type and luminosity we can now select a normal F-type spectrum for comparison. After an inspection of several stars, ι Piscium was chosen. Its spectral type is F8 and its absolute magnitude is + 3.5, so it is a good match for the brighter component of H.D. 144208-9.

Line profiles for the *K* line of Ca II and the hydrogen lines are shown in Figs. 2 and 3 respectively. The composite spectrum is designated by filled circles and the profiles of the spectral lines of ι Piscium by open circles. The effects stated in (ii), above, are brought out very clearly by this comparison and it is proposed to

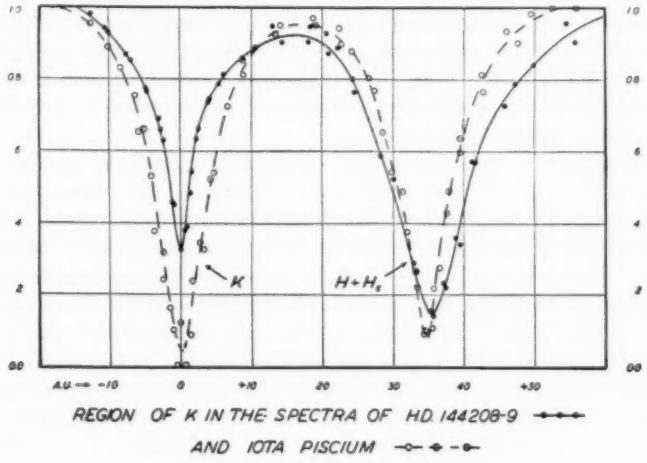


Fig. 2

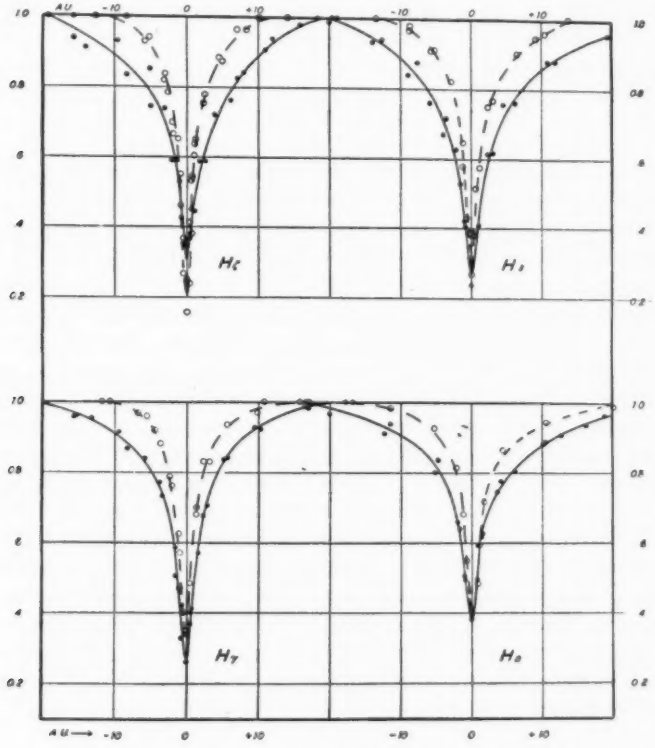
derive from them the relative light, spectral type, and surface temperature of the fainter component of H.D. 144208-9. The investigation follows lines similar to those used by Wilson and Christie[7] in a study of ζ Aurigae and by Goedecke[8] in a study of VV Cephei. In our case, however, conditions are not so favourable for accurate results since it is necessary to use an external source of comparison and the differences to be measured are not large.

[7] *Astroph. Jour.*, vol. 81, p. 426, 1935; [8] *Pub. Obs. Univ. Mich.*, vol. 8, p. 1, 1939.

Consider the result of combining two spectra originating in separate stars, the luminosity of the fainter star being l times that of the brighter. The intensity in the combined spectral line r in terms of the combined continuous spectrum is then

$$r = \frac{r_b + l r_f}{1 + l}, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where r_b and r_f refer to the line intensities in the spectra of the



HYDROGEN LINES IN THE SPECTRA OF HD 144208-9 —•—•—
AND IOTA PISCIUM -o- - o - o-

Fig. 3

brighter and fainter stars respectively. It then follows that the absorption in the combined line is, in terms of those in the separate companions,

$$a = \frac{a_b + la_f}{1 + l}, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

If we now integrate (2) so as to deal with total absorptions, symbolized by capital letters, we have

$$A = \frac{A_b + lA_f}{1 + l},$$

whence

$$l = \frac{A - A_b}{A_f - A}. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

We may then determine l from the measured total absorption A, in the composition, provided the total absorption A_b and A_f are known. The quantity A_b is derived from the spectrum of the comparison star ι Piscium and assumed to be the same as that in the spectrum of the solar-type component. The value of A_f is not so readily obtained since one must adopt a value appropriate to the spectral type of the fainter component. It will be shown, however, that the proper choice can be made without much ambiguity. In passing it may be noted that one may secure a minimum value of l from the K line by placing $A_f = 0$. This is equivalent to assuming that the fainter star has no K line but adds only continuous spectrum to the composition. This minimum value of l is very useful as a check upon the values of A_f which are permissible for the other spectral lines.

An alternative method for deriving l at various wave-lengths is provided by the comparison of central depths of the narrow metallic lines in the composite spectrum and in the comparison spectrum, assuming that the fainter component contributes only continuous spectrum to the composition. If we let a_0 be the observed central depth in the composite spectrum and a_c be that in the comparison then we have,

$$l = \frac{a_c}{a_0} - 1; \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

from which the values of l at various wave-lengths may be obtained. While this second method appears very promising, theoretically, it

was found to be not satisfactory in practice, in this case at least. The distortion of fine spectral lines due to the low resolving power and the serious effects of blending with adjacent spectral features combine to render the line-depths unreliable. For these reasons it was decided to employ only the measures of total absorption for the Balmer lines, and for K, to determine the course of the $l-\lambda$ relation. The objections to the use of line-depths would not have the same force were the spectra obtained with high dispersion and resolving power and if the two component stars differed by three or more spectral divisions. Under such favourable circumstances it is expected that good results would be obtained from line-depth measures of a large number of narrow, deep spectral lines.

Returning now to the line profiles of Figs. 2 and 3, the effect of the fainter component is easily seen by comparison with the line profiles in the spectrum of ι Piscium. The weakening of the K line in the composite spectrum is very evident, the effect at H is masked and even reversed, due to the strengthening of the hydrogen component Hϵ. It is also quite clear that the hydrogen lines in the composite spectrum are broader than one would expect in the normal solar type. It is to be noted furthermore, that this strengthening of the wings of the Balmer lines proves that the fainter component of the composite system must have very intense hydrogen absorption lines.

The measurements of line intensities for H.D. 144208-9 and for ι Piscium are given in Table II, the equivalent widths, in angstrom units, being tabulated.

TABLE II

Absorption Line Intensities

Line	Intensity	
	H.D. 144208-9	ι Piscium
K	5.85 A.U.	9.91 A.U.
Hζ	6.41	3.31
Hδ	7.53	3.72
Hγ	5.87	2.99
Hβ	6.26	3.66

In order to derive l from these data it is necessary to adopt values of A_f for use in formula (3) where A_f is the intensity of the line in the spectrum of the secondary star. In order to facilitate this, curves relating spectral type and mean line-intensity were constructed so that values of A_f could be read for any spectral subdivision. In forming the curves the line-intensity measures of Gunther,[9], E. G. Williams[10] and Miss E. T. R. Williams[11] were used, omitting the "c" stars. Substitution of the values given in Table II together with various values for A_f into formula (3) enables us to determine l for any assigned spectral type of the secondary star. The values of l, so derived for different spectral subdivisions, are listed in Table III.

TABLE III

VALUES OF l FOR ASSIGNED SECONDARY SPECTRUM

Assigned Spectrum	Values of l				
	K	Hζ	Hδ	Hγ	Hβ
B5	+0.75	−2.60	−3.20	+4.06	−10.8
B8	0.77	+1.37	+2.60	0.90	+0.81
A0	0.87	0.70	0.73	0.45	0.45
A2	1.18	0.61	0.53	0.33	0.43
A5	3.03	0.77	0.66	0.37	0.55

A study of Table III is very instructive in deciding the spectral type of the fainter star and determining l. The values derived from the K line demonstrate that the fainter star cannot actually be the less luminous and have spectral features corresponding to a type later than A0. On the other hand, the results from the hydrogen lines show that the spectrum cannot be earlier than A0, and so the secondary star's spectral type is limited to a narrow range in the neighbourhood of A0. We have thus determined the type of the

[9] *Zeits. f. Astrophysik*, vol. 6, p. 106, 1933.

[10] *Ann. Solar Obs'y Camb.*, vol. 2, pt. 2, 1932; *Astroph. Jour.*, vol. 83, p. 279, 1936.

[11] *Harv. Circ.*, No. 348, 1929.

unknown spectrum and the values of l at several wave-lengths. The adopted values of l are those enclosed by the dotted lines in Table III.

Having values of l at several wave-lengths we may now derive the temperature of the fainter star, if we assume a temperature for the brighter solar-type component. To do this we plot the values of $\log_{10} l$ against the reciprocal of the wave-length and find the best straight-line relation between them. This is, of course, the familiar method of gradients and need not be elaborated upon here. If we adopt a temperature of 6000°K. for the brighter component, dF9, then the resulting temperature for the fainter star is

$$T = 12{,}500°\text{K.} \pm 3100°\text{K.}$$

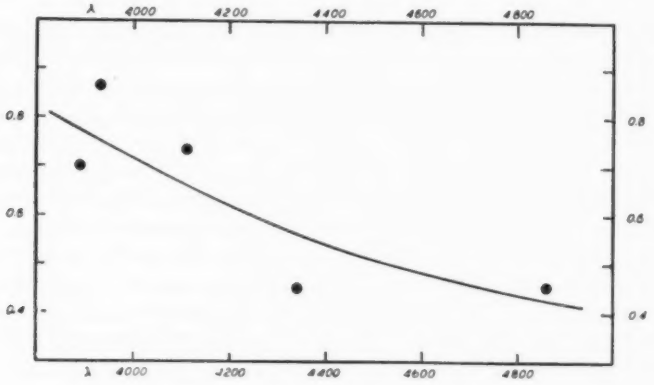


Fig. 4

This value is in satisfactory agreement with the conclusion that the fainter star is of spectral class A0. The large probable error is caused, to a considerable degree, by the restricted range in wave-length over which l was measured. Had the measures been extended to Hα a substantial reduction in probable error would have ensued, while the value of the temperature would not have altered very much.

The values of l are plotted against wave-length in Fig. 4, the

curve corresponding to the temperature 12,500°K. being drawn. As a final step we may compute the value of l for any wave-length and so derive the difference in visual magnitude between the two components. Referring to the brighter star by subscript A we have,

$$\Delta m = 1.17,\ m_A = 6.17,\ m_B + 7.34,$$

while, adopting the Mount Wilson value for the absolute magnitude of the bright component, we derive,

$$M_A = +3.4,\ M_B = +4.6,\ \pi = 0''028.$$

Section III. The System of H.D. 144208-9

We are now in a position to calculate certain of the dimensions of the system and components of H.D. 144208-9. The radii of the components may be obtained from the absolute magnitudes and temperatures derived in the previous section. An idea of the mass of the F-type star may be obtained from the mass-luminosity relation and comparison with the "projected" mass derived from the orbital elements will give the inclination of the orbital plane. For this purpose the bolometric corrections and mass-luminosity relation derived by Kuiper[12] were used. The absolute dimensions of the orbits may then be computed and also the mass of the fainter star. Finally, the mean densities follow from the masses and radii.

The principal dimensions are tabulated in Table IV, and it will be apparent from them that H.D. 144208-9 is a system peculiar in some respects. The brighter component is a normal solar-type star possessing mass, luminosity, and density typical of the main stellar sequence.

TABLE IV

The System of H.D. 144208-9

	Primary	Secondary
Spectral Type	dF9	A0
Absolute Magnitude	+ 3.4	+ 4.6
Surface Temperature	6,000°K.	12,500°K.
Mass	1.5⊙	1.3⊙
Radius	1.6⊙	0.35⊙
Mean Density	0.4⊙	30 ⊙
Orbital Radius	42×10^6kms.	50×10^6kms.

[12] *Astroph. Jour.*, vol. 88, p. 429, 1938.

The fainter star is, however, quite remarkable. Its surface temperature and spectral features indicate a star of early spectral type, probably A0. And yet this star is of the same luminosity as the sun whereas the normal A0 star is about one-hundred times that brightness. Furthermore, its radius is only a fraction of the normal value, its mass is probably less than average, while its mean density is very large, probably a thousand times the normal value for an A0 star. Thus, in spite of the uncertainties attending some of the calculations it may be taken as established that the fainter component of this binary system is a sub-luminous, highly-compressed, object which does not belong to the main stellar sequence. To such a star the name sub-dwarf has been applied.

It might be argued that since the sub-dwarf star has high surface gravity the hydrogen lines would be stronger than those in the average A0 star, and therefore the procedure used in finding l is invalid. If the adopted values of A_f which were substituted in equation (3) were too small then the values of l, derived from the hydrogen lines and given in Table III, would be too great. This hypothesis, however, is not in accordance with the value of l derived from the K line of calcium. In any case if we have adopted values of l which are too large, then corrected values increase Δm and would result in a higher surface temperature and smaller radius for the companion. All this would merely strengthen the evidence in favour of the sub-dwarf nature of the fainter component.

In conclusion it may be remarked that, among the binary systems exhibiting composite spectra, there are a number which resemble H.D. 144208-9. Among the composite spectra in the catalogue compiled by Hynek[1] eighteen systems have been noted as possessing sub-dwarf secondaries.[13] Attention is directed to this point because of the value of spectroscopic investigations of these special binary systems. At the present time this appears to be the most promising way to obtain reliable knowledge of the luminosities, masses, radii, and mean densities of these interesting sub-luminous stars.

Dominion Astrophysical Observatory,
Victoria, B.C.
March 25, 1943.

[13]This matter is the subject of a separate note by the writer in *Pub. Ast. Soc. Pac.*, October, 1942.

REVIEW OF PUBLICATIONS

Air Navigation for Beginners, by Scott G. Lamb, pp. 102. *A Start in Meteorology,* by Armand Spitz, pp. 95, 5½ x 8 inches, Norman Henley Publishing Co., New York. Price $1.50 each.

These two small books are designed as primers for young people who are interested in various branches of aviation. They are prepared with the cooperation of the Junior Air Reserve of the National Aeronautic Association. Both authors are instructors in their respective fields in the Air-Mar Navigation Schools of the Franklin Institute.

Lieutenant Commander Lamb writes in a very authoritative manner on navigation. His task was to compress into seventy-two pages of text most of the branches of air navigation. When such diverse fields as instruments, maps, pilotage, dead reckoning, radio range, aerial astronomy and time are included in such a small compass, it is obvious that the total information in any one field is very limited. Readers in this country would notice that the Mercator projection is, by our standards, underemphasized. Also, sidereal hour angle, as now used in both Britain and the United States, is not discussed in this book, though sidereal time is described. The book seems, to this reviewer, to be much too condensed for beginners, and much too expensive for its size.

The companion volume, *A Start in Meteorology,* is even shorter, the body of the text occupying only some sixty pages. The author has, however, succeeded in making a very readable and informative primer of meteorology. It will undoubtedly inspire readers to watch the weather more carefully and to read further works. The book is very plentifully illustrated by sketches. Most readers will probably have enough familiarity with other elementary scientific books to feel that the diagrams here reproduced are needlessly rough in workmanship, even for a book admittedly planned, prepared and published at high speed. As with the previous book, the price seems too high, despite the many good properties of this book.

F. S. H.

Astronomical Society of the Pacific Leaflets, Vol. III, Leaflets 101-150. Pages 407, 4 x 7¼ in. San Francisco, Published by the Society, 1943. Price $3.00.

Some seventeen years ago the Astronomical Society of the Pacific began the issue of its Leaflets which have now become a regular monthly publication highly valued by the members of the Society and by many others. Each contains a short essay on some astronomical or closely related topic, written by one thoroughly familiar with his subject. At first they were limited to four pages and the type used was rather small, but latterly they have usually contained eight pages of larger type. This form has been much more satisfactory. It has shown that within this compass a competent writer can give a clear and quite understandable account of a somewhat difficult subject which can be read in less than half an hour.

The authors are mostly connected with the great observatories on the Pacific coast. The subjects vary widely and are chosen for their immediate interest, but in no case, it may be said, is that interest ephemeral. Indeed any article in the collection could be picked up to-day or twenty years hence and perused with pleasure and profit.

Of the fifty leaflets in the present volume R. G. Aitken contributes 8, R. S. Richardson 4, D. H. Menzel, P. W. Merrill, N. U. Mayall, R. F. Sanford, S. A. and M. L. Ionides, A. B. Wyse, and G. F. Mulders 2 each, and so on.

The publication of the volumes was made possible by a bequest from one of the Society's former members and the editions are limited to 500 copies. A few copies of volumes I and II, we are told, are still available at $1.50 each. Vol. III has a subject index to all the Leaflets from 1 to 150.

The present volume of Leaflets recalls the publication by the Society in 1919 of the *Adolfo Stahl Lectures in Astronomy,* which contained twelve lectures delivered under the auspices of the Society in 1916-17 and 1917-18, by distinguished astronomers, and financed by Adolfo Stahl. The treatment of the topics was fuller but there was the same lucid presentation by men thoroughly master of their subjects. To the present reviewer it has always seemed very interesting and of permanent value.

C. A. C.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Nova Herculis (1934) and Kepler's Great Nova (1604)

From the Annual Report of the Director of the Mount Wilson Observatory issued December 18, 1942, the following information regarding these two famous stars is extracted.

Investigations of galactic nebulae have to a large extent centered about those nebulae associated with outbursts of novae or supernovae. Direct photographs and spectroscopic studies of Nova Herculis (1934) show the emergence of an elliptical ring due to an expanding shell of finite thickness. The clearly separated diffuse and filamentary nebulosities of the Crab nebula, probably a remnant of the supernova of 1054, have quite different spectra, that of the diffuse part being continuous, that of the filaments consisting of bright lines. Theoretical considerations indicate that the supernova before its outburst was a massive star of low hydrogen content, and that the greater part of its mass was lost in the outbreak, leaving a relative small star of high temperature.

An interesting and somewhat dramatic discovery is that a small fan-shaped nebula and various wisps of nebulosity scattered over a field 80″ in diameter in the constellation of Ophiuchus are almost certainly remnants of Kepler's supernova of 1604. The region is heavily obscured, but the spectral characteristics of the fan-shaped nebulosity and its relatively high radial velocity afford strong evidence that it forms part of an expanding nebula.

C. A. C.

The Parody on "Twinkle, Twinkle!"

In response to a request for information on a parody on "Twinkle, twinkle, little star," in the May-June issue, p. 218, a correspondent in Prince George, B.C., writes:—

I enclose three stanzas which I cut from an English newspaper for my scrap book probably about sixty years ago. As the scrap book went into the discard long since I have written from memory, but think they are fairly correct. I have no knowledge of the author.

Scintillate, scintillate, globule vivific!
Fain would I fathom thy nature specific.
Loftily poised in the ether capacious
Strongly resembling a gem carbonaceous.

When torrid Phœbus refuses his presence
And ceases to lamp us with fierce incandescence,
Then you illumine the regions supernal.—
Scintillate, scintillate, semper nocturnal.

Then the rude victim of peregrination
Gratefully hails your minute conflagration;
He could not determine his journey's direction
Except for your bright, scintillating protection.

C. A. C.

Singing Sands in the Gobi Desert

The place is the shore of Nan-hu (South Lake) in longitude 95° E. and latitude 40° N. The writer is Mildred Cable in *The Gobi Desert,* p. 63, London, 1942.

The constant hurricanes which sweep the sandy plains have piled up a long line of dunes stretching from Tunwhang away to the Desert of Lob. The range is so long, and the hills are so lofty, and so massed one behind the other, that it seemed incredible such a mighty rampart could be composed wholly of shifting sand. From season to season the contour of the dunes changes, for under the breath of even the lightest breeze the shifting surface runs like sand in an hour-glass, and every wind lifts the clear-cut ridge like spray, though the solid body of the sand-mountain resists the fiercest winter storms.

* * *

Within an hour we were standing at the base of the outermost hill, and where the range was at its lowest we started to climb the steep side, ploughing upwards through sand which buried our feet to the ankle at each step. Near the top, where the slope was almost perpendicular, exhaustion overcame us and every few steps we sank to the ground. All around us we saw tier on tier of lofty sand-hills, giving the lie to our quest, yet when, with a final desperate effort, we hoisted ourselves over the last ridge and look down on what lay beyond, we saw the lake below, and its beauty was entrancing. . . . The downward stretch of the soft slope was an irresistible inducement to slide, and we all came down with a rush, bringing the sand with us like a cataract. Then, for the first time, we experienced the strange sensation of vibrant sands, for as we slid a loud noise came from the very depths of the hill on which we were, and simultaneously a strong vibration shook the dune as though the strings of some gigantic musical instrument were twanged beneath us. We had, unknowingly, chosen for our slide one of the resonant surfaces of the hill, for, curiously enough, only a few of the dunes are musical and most of them are as silent as they are dead.

The long descent landed us on the edge of the lake and a short distance from the temple door, where the priest received us and led us to a pleasant room in the guests' courtyard.

"You heard the *lui-ing* (thunder-roll) of the hills as you came down," he said. "The sound reached us here, for you chose the right spot to set the sands thundering. Had you been a little farther to the east or west, the noise would

have been much fainter, and had you come down that farther hill, nothing would have been heard."

"I never knew sands with a 'thunder-voice' before," I said.

"You will hear it often while you stay here," was his answer.

This was true, and whenever the wind blew in a certain quarter a roaring came from the dunes. Once, at midnight, we were awakened by a sound like a roll of drums. On that occasion there were brigands in the neighborhood, and I jumped up in alarm, fearing an attack, but the priest heard me and called out:

"Don't be anxious, Lady. It is only the drum-roll of our sand-hills. Rest your heart."

C. A. C.

Observation of the Perseid Meteors, 1943

Through the absence on military duty of Dr. P. M. Millman and other members of the staff, as well as a shortage of observers, no organized effort was made at the David Dunlap Observatory to observe the Perseid meteors this summer. It gives pleasure to learn that the phenomenon was not overlooked in some parts of the country. Under date August 16, Mrs. W. T. Scheffer, of 10 So. 19th St., Harrisburg, Pa., sends the following note along with the sketch she refers to.

I am enclosing a rough sketch of a view of the sky from my east window on the morning of August 12. Frequently in my lifetime I have sat up to watch for shooting stars, hoping I might see something like the shower of November 13, 1833. The most I have ever seen was 8, but last week I saw 21 in the two hours (3-5 a.m.) I sat up.

C. A. C.

Observatory and Equipment for Sale

Mr. H. Boyd Brydon of Victoria, B.C., who is well known to members of the R.A.S.C. through his contributions to this Journal, reports that he has been compelled to give up observational work and wishes to dispose of his observatory and its equipment. The telescope was purchased in 1931 from the accomplished amateur A. F. Miller of Toronto (still living, age 90). Mr. Brydon's address is 2390 Oak Bay Ave., Victoria, B.C.

Description of Equipment

The telescope is an equatorially mounted, clock-driven, 4-in. refractor, supported on a 5 ft. 6 in. heavy cast iron pillar. The telescope objective is by

Wray, the famous London lens-maker. It gives beautiful definition. The body of the telescope is by James Foster of Toronto. Two draw tubes and focussing tube are fitted.

The equatorial mounting, by Stewart of London, is of brass and gun metal and is of substantial proportions. The hour and declination circles are graduated on silver and are each provided with two verniers reading to 5 sec. of time and 1 min. of arc respectively. The hour circle is of Airy's design which permits setting the telescope on the desired object without calculation. Both circles are read by miscroscopes and are fitted with low-voltage electric illumination, served by an adjustable voltage transformer from the ordinary lighting mains.

Clamps and slow motions are provided for control of the telescope from the eyepiece.

The driving clock, also by Stewart of London, is weight driven. The speed is controlled by an adjustable centrifugal governor.

The telescope is provided with a battery of seven achromatic eyepieces giving magnifications of 30, 60, 120, 180, 210, 240 and 300, also with an achromatic Barlow lens of 8-in. negative focus, by which the power of any of these eyepieces can be increased as desired to approximately twice the above.

The finder has an objective of 1⅛-in. diam. and is arranged for electric illumination of the cross wires.

There are also the following accessories:

A Herschel wedge diagonal for solar observation, also several eye-shades of neutral tint and an adjustable neutral-tinted glass wedge, all suitably mounted for attachment to an eyepiece.

A prism star diagonal for convenience in observing zenithal stars.

A Hilger 5-prism McClean Spectroscope for use with a telescope eyepiece.

A Simms filar micrometer with two eyepieces, position circle and graduated micrometer head, the wires arranged for electric illumination.

A Browning Spectroscope having an original Rowland-Brashear grating ruled on Speculum metal, 14436 lines on a 1-in. square space, mounted on a graduated rotatable stage with tangent screw. The collimator and telescope have 1-in. objectives. The slit is adjustable. Two eyepieces are provided. A supporting rod and clamp for attachment to the telescope are provided.

A pancratic terrestrial eyepiece.

C. A. C.

Binding of Volumes of the Journal for Members

In the April issue a plan was outlined by which members could participate in a group order for binding back volumes of their Journals. Arrangements are now substantially complete. The binding will be in a good grade of blue cloth, the price not to exceed $1.50 per volume. Will anyone wishing to have back volumes bound under these conditions please mail them, as soon as possible, to the Editors, David Dunlap Observatory, Richmond Hill, Ontario?

F. S. H.

MEETINGS OF THE SOCIETY

AT VICTORIA

January 21, 1943.—The meeting was opened at 8.15 p.m. by the President, Mr. O. M. Prentice. Mr. H. F. Ponsford was elected a member of the Society.

Dr. C. S. Beals of the Dominion Astrophysical Observatory, Victoria, gave a very clear and interesting talk on "The Fundamentals of Spectroscopy." He explained that the purpose of spectroscopy was to analyse light and to discuss the origin of it. By means of many practical demonstrations the main points of the lecture were clearly illustrated. Dr. Beals projected a spot of light on the screen and by means of coloured filters showed that this spot contained red, blue, green and violet light. He illustrated the principle of the prism which gives greater dispersion of light at the violet end and the grating, which is a plate of speculum metal on which many fine parallel grooves are ruled, perhaps 15,000 lines to the inch, which is more efficient in the red and yellow region.

A continuous spectrum, which is produced by an incandescent solid or liquid or a gas at high temperature and density, was projected on the screen and it was explained that it was made up of millions of images of the source. Continuous absorption was shown by putting different coloured filters in front of the source. Emission line spectra are formed when an electric current is passed through a gas in a sealed tube. The mercury vapour lamp produced this type of spectrum—consisting of 3 lines, in the yellow, green and blue regions. It was emphasized that the emission lines were simply an image of the source and could be of any shape. Absorption line spectra are formed when an absorbing body is placed in front of a continuous spectrum.

The colour does not give enough distinction to identify the lines, so they are designated by wave-length. A frequency chart of wave-lengths was shown, illustrating the small portion of electro-magnetic waves which is in the form of visible light. The 15-mile-long radio waves and the minute cosmic waves of 4×10^{-12} cm. extend on either extreme end of the visible spectrum. Each element has its distinct spectrum under the same physical conditions. By comparing the absorption or emission lines in the star's spectrum with those of iron which contains many lines, iron and other elements can be discovered in the star's atmosphere. Finally Dr. Beals explained that in the Bohr model of the atom, when an electron jumps from a high-energy level to a lower one, radiation is emitted, producing emission line; and, conversely, when the electron jumps from a low-energy level to a high one an absorption line is formed. Each line corresponds to a line in the spectrum of that element.

February 17, 1943.—The meeting was called to order by the president, Mr. O. M. Prentice, who announced that, due to dim-out regulations, Victoria College would no longer be available for meetings of the Society. After the minutes of the previous meeting were adopted, Mr. Peters presented the current

phenomena in the form of an Astronomical Fable in which the audience were to pick out all mistakes; this feature proved highly entertaining.

The speaker of the evening was Mr. G. C. Brown-Cave, Chief Analyst of the B.C. Department of Mines, who had chosen for his lecture "The Spectro-chemical Analysis of Ores and Minerals." A brief review of spectroscopy was first presented in which it was shown that white light could be broken up into the rainbow colours by means of a prism and each colour had its own range of wave-lengths. In answer to the question, "What produces light?" the speaker told how ordinary matter is made up of molecules which may be broken up into electrons and each of the 92 (or possibly 95) elements has a different number of electrons in the atom. Mr. Brown-Cave spoke of the different energy levels within an atom and how an electron may jump from one level to another to produce a given wave-length of light; as each atom has its own characteristic set of energy levels, it also emits its own set of wave-lengths or colours under suitable conditions. This is the principle of spectro-chemical analysis.

In practice, 10 milligrams of the ore to be examined are placed in the crater of a carbon arc and the light from the arc is passed through a spectrograph onto a photographic film. Several examples of these films were shown and the audience could see how samples of silver, iron, tin or tungsten could be distinguished very easily; thus the qualitative analysis of any ore could be made very quickly. Mr. Brown-Cave finally discussed the quantitative analysis of ores and showed how the amounts of each metal in a given sample could be determined in a matter of hours by this powerful new method, whereas it might take weeks if the older methods of chemical analysis were used.

In answer to questions, the speaker said that the amount of a given metal in a sample of ore could be determined within 5 per cent by spectro-chemical means.

K. O. Wright, *for Recorder.*

March 24, 1943.—The meeting was called to order at 8.10 p.m. by the president, Mr. O. M. Prentice. Mr. McIntosh was elected a member on the motion of Mr. Ponsford, seconded by Mrs. Yarwood. Mr. Prentice introduced the speaker, Mr. William Petrie, University of British Columbia, whose subject was "The Riddle of the Corona."

Mr. Petrie began by drawing to the attention of the audience the importance of the sun which is the source of all forms of energy, radiating 4×10^{33} ergs per second, and that we must study the sun in order to understand better the nature of the stars. Lantern slides were shown illustrating the surface of the sun which is in a very unstable gaseous state. Some of the features are the sun-spots which are large areas moving in vortices, and associated with magnetic fields. Prominences are caused by explosions and upheavals, supported by magnetic fields. They are of 3 types: (1) Quiescent—which remain stationary for hours or days; (2) Eruptive—which arise quickly and sometimes only last for minutes; and (3) Coronal type—which appear to condense high above the solar surface and then travel downward.

The corona is the diffuse outer atmosphere extending a million miles beyond

the surface of the sun, only visible during a total solar eclipse. It takes two forms—the maximum corona, when the sun-spots are most numerous, at which time it is evenly distributed around the solar sphere; and the minimum corona, which is in the form of streamers and occurs when the sun-spots are at a minimum.

In 1869 bright lines of the corona spectrum were observed. From that date until 1941, the elements producing these lines were not known. They were referred to as arising from "coronium." Then Edlen suggested that the three brightest lines were due to iron, nickel, and cobalt, which had many electrons removed. This can occur only in very high temperatures of at least 100,000°. The lines were also broad and fuzzy which also indicates a high temperature. Another confirmation of the high temperature of the corona is the fact that no hydrogen lines are found. This would be the case when the simple hydrogen atom is broken up and the free electrons are moving so quickly that they cannot be recaptured. Thus there is much evidence for the theory that the corona is caused from material of a very high temperature ejected from the centre of the sun. This also offers an explanation for the coronal prominences, which are too hot to be seen as they are ejected and just become visible as they are ready to come down to the surface of the sun again.

There is still a long way to go in the quantitative study of the corona, which is now being conducted at two observatories, one in France and one at Harvard Observatory Station at Climax, Colorado.

There were many questions asked about the work at the Climax Station and about the high temperatures referred to.

E. WALKER, *Recorder.*

April 21, 1943.—The meeting was called to order at 8:15 p.m. by Dr. Andrew McKellar, vice-president. Mr. A. F. Mitchell and Mr. N. B. Ashwood were elected members. Dr. McKellar announced that tentative plans had been made to hold the usual summer course in astronomy.

Mr. Robert Peters gave a very interesting talk on current phenomena, remarking on the fact that Easter this year is later than it will be again this century. Mercury will be visible early in May in the evening sky near the Pleiades. Dr. McKellar showed a few slides illustrating the aluminizing of the 72-inch mirror at the Dominion Astrophysical Observatory. He showed that aluminum was a much better reflector than silver in the violet region of the spectrum.

The speaker of the evening, Dr. K. O. Wright, of the Dominion Astrophysical Observatory, in his lecture "The Constitution of the Stars" continued the series of lectures on spectroscopy. He began by presenting a brief review of the study of the sun's atmosphere, the corona, chromosphere, reversing layer, and photosphere, and the principles underlying the production of continuous, absorption and emission spectra. Sixty of the ninety-two elements present on the earth have been found in the sun's atmosphere. Slides were shown illustrating the sizes and brightness of the stars. If the brightest star is

represented as a searchlight, then the sun is like an ordinary lamp and the faintest star is as bright as a firefly. The structure of the atom was described, and the different energy levels of the atom illustrating how the normal, excited and ionized atoms are formed. In the Ca atom, for instance, radiation from the star in form of a high-energy photon hits the atom and knocks an electron from the normal level to the next level, forming an excited atom which produces a line in the blue region. If the star is of a higher temperature more electrons are knocked completely out of the atom, producing an ionized atom which gives a line of shorter wave-length in the violet. In the lower-temperature stars there are more normal atoms, fewer excited atoms but more ionized atoms since once an electron is lost there is not enough energy for the atom to gain it back again. Usually the increase in the number of atoms results in more and stronger lines. This was illustrated by a drawing of the curve of growth where intensity of the line is plotted against the number of atoms.

From Dr. Wright's study of four solar-type stars, two giants and two dwarfs, and comparisons of their curves of growth, he found that the turbulent velocity is greater in giants and the flat part of the curve of growth is higher. The giants have a higher excitation temperature than the dwarfs, and the four stars vary little in composition.

Dr. Wright concluded by stating how much astronomers owe to the science of physics in their search for knowledge of the composition of the stars.

E. WALKER, *Recorder.*

AT EDMONTON

January 14, 1943.—The president called for order at 8.20 p.m..

The librarian described the library and its location for the benefit of new members. Books are normally changed between the meeting and the refreshment time. Mr. Wates has presented a bound pamphlet entitled "Does Anything Ever Happen on the Moon?"

Applications for membership were presented on behalf of Mr. J. M. Tait (regular) Mr. S. G. Deane and Mr. V. Nyberg (associate). On a motion by Mr. Doughty and Mr. Blue the secretary was instructed to cast a ballot electing these members.

The usual HANDBOOK talk was given by Mr. Wates. Sunset may be pictured as the horizon sweeping up to meet and eclipse the sun. Over the same period in January there is an 11-minute difference in sunrise compared to a 24-minute difference in sunset time.

The secretary gave a short talk on the constellations Taurus, Orion.

The main paper was on "Meteorites" by H. B. Collier. Meteorite material is truly a message from another world. There are millions per day caught by the atmosphere, but only 1,000 are recorded in history as reaching the ground. The earth meets most meteors head on at about 40 miles per second. They are hot outside and cold inside if of large size. Beautiful slides of many of the world's largest examples were shown and described. One showed children lying in the hollows that have rusted away.

Mr. Wates explained fragmentation by the heat of impact. Also in some slow meteors the orbital speed of the earth is subtracted from the speed of the meteorite with respect to the sun.

Dr. Revell explained that the word meteor means something in the air, while meteorite describes one that has fallen to the earth. He suggested that the scratches shown on some fracture surfaces could be made by very small movement.

February 11, 1943.—The meeting was called to order at 8.16 p.m.

New business: Moved by Mrs. Clarke, seconded by Dr. Revell, that the meeting adjourn to the new Observatory after the HANDBOOK talk. Carried.

The HANDBOOK talk was given by Mr. Wates. He reported that Nova Puppis was as bright as Rigel in November, but cannot be found on previous plates showing stars down to the 18th magnitude. This means it became 100,000 times as bright as the sun. There have been seven bight novae in the first 43 years of this century, whereas there was only one in the whole 19th century.

Application for regular membership had been received from

Miss Anna Malanchuk

Mr. W. E. Mjolsness (who was once an Associate)

It was moved by Mr. Blue, seconded by Dr. Revell, that the secretary cast a ballot electing these applicants to membership.

March 11, 1934.—The president called the meeting to order at 8.16 p.m.

It was reported that several people saw the eclipse of the moon under very favourable conditions. The secretary read a letter from a member who now lives in Cleveland, Ohio,—Clinton Constant.

Mr. Wates gave the usual HANDBOOK talk. No one had the answer to his question,—the moon is in syzygy at conjunction or opposition, i.e., when in the plane of the earth's orbit. He described the shadows and transits of moons I and II across the face of Jupiter, and asked this question for next meeting: the shadow can be seen with a 12-inch telescope,—possibly both the shadow and the satellite could be seen with the 72-inch telescope in Victoria. Why?

Mr. Smith asked if the amount of the moon eclipsed was the same to observers at different parts of the earth. The answer was yes, except for the small effect due to libration. He also asked why the elements of the various planets were different. The similarity, not the differences, is the surprising thing, not expected unless they have a common origin.

The constellations Gemini and Cancer were shown as slides by Dr. Gowan, and briefly described.

Co-ordinate systems were described by Mr. Stockwell. He explained the meanings of the various terms in astronomical co-ordinates, and left them on the board for reference. The location of the position of Regulus was worked out in detail, and shown on diagrams in the several necessary stages. The measurements were then transferred to the azimuth and altitude system.

In illustrations of the above Dr. Campbell demonstrated the wooden astrolabe in action. It is also used "in reverse" for identifying a star. Altitude and azimuth are observed, transferred to right ascension and declination. The catalogue can be consulted using these, and the star identified. The important extension to telescopes with polar axes was described.

April 8, 1943.—The president called the meeting to order at 8.17 p.m.

It was resolved that the Centre frame the memorial picture of Copernicus (being donated by the University Library) and have it hung in the new Observatory.

Dr. Campbell announced that there would be a special programme at the May meeting in commemoration of the death of Copernicus, which took place May 24, 1543.

Mr. Doughty exhibited an old and rare book on Agriculture, or the Mystery of Husbandry Discovered, 1681. He read some interesting extracts dealing with the effects on the weather of such things as the appearance of the sun, the moon, comets, stars, the rainbow, and the barometer.

Mr. Wates gave the regular HANDBOOK talk. Tables show unequal days and nights at the equinox, as has been mentioned in the papers recently. The tables refer to the upper limb of the sun, and allow for refraction. The day of astronomical equinox is when the centre of the sun is on the horizon at 6 o'clock. The difference gives a day which is 11.5 minutes longer at March 21. No one had the answer to the question propounded at the March meeting. The shadow is dark and is seen against a bright background. The satellite is almost as bright as the planet, and therefore extremely difficult to see. But satellites have no atmosphere, and their dark patches might be resolved in a large telescope. The question for next meeting is: Can the crescent of Venus be seen by the naked eye through smoke or steam which cuts down the glare?

Miss Jean Wallbridge was called upon for the main paper on Saturn. Stars twinkle, planets do not, which helps in identifying them. Saturn advances in the sky for seven months, and then retrogrades for five months. The rings were first thought to be other stars, then handles, and finally with Huygens' better telescope were seen to be thin rings. These were first thought solid, but have been proved by theory and experiment to be made up of many fragments or meteors. The divisions in the ring system are due to the influence of the satellites, and are illustrations of the principle of resonance. The surface temperature is —250°F. The diameter is 9 times that of the earth, and the specific gravity is 0.7. The atmosphere is the most important part of the planet, and contains a large amount of hydrogen, since the large gravity gives a large velocity of escape. There are bands on the surface, which is the shape of a flattened spheroid. Of the nine very different moons, one moves in a retrograde sense. There is no possibility of life as we know it.

May 13, 1943.—The president called the meeting to order at 8.19 p.m.

The secretary reported that the picture of Copernicus was framed and

ready for hanging. It was moved by Mr. Blue, seconded by Miss Wallbridge, and carried, that Dr. Gowan be responsible for hanging the picture in the Observatory.

It was moved by Mr. Stockwell, seconded by Mr. Smith, and carried, that the model of the moon, and its accompanying key be suitably mounted in the Observatory.

On the motion of Mr. Hamilton and Mr. Volker the secretary was instructed to cast a ballot electing the following two candidates:

Professor A. L. Cru, University of Alberta.

Mr. H. J. Montgomery, 11317-64 St., Edmonton.

The usual talk on the HANDBOOK was given by Mr. Wates. This included some tests on the visibility of the crescent of Venus. A dime at 200 feet subtends the same angle.

Mr. Wates also showed a slide rule to be mounted by the clock in the Observatory. It makes easy the transposing from declination to hour angle for setting the telescope.

In commemoration of the 400th anniversary of the death of Copernicus Mr. L. H. Nichols delivered the main paper. Copernicus was greatly influenced by, and carried along with the rising tide of the Renaissance, and still was far ahead of his fellows. Planetary motions on the Ptolemaic system were described, and contrasted with the retrograde motions of Jupiter as an example of the sort of observation which had to be explained. There were many difficulties of conception which had to be argued away. The details of the motions were not so very different in the heliocentric system with circular orbits. This still needed the complications due to the introduction of epicycles, and therefore simplicity could not be used as an argument in its favour at that stage. Also there was no published account to make easy a general comparison with the geocentric theory. The greatness of the conception and Copernicus' faith in it are outstanding as compared with the details. A new picture is necessary in breaking the bonds of the old hide-bound ideas. This is important and useful in the sense that it must precede the development of other useful or applied knowledge.

Dr. Campbell remarked that the heliocentric idea was not new. It was introduced by the Greeks, but the prestige of Hipparchus as a practical astronomer overwhelmed the theories of Aristarchus, which we now believe correct.

E. H. GOWAN, *Honorary Secretary.*

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